STANFORD ENGINEERING

Lunar Prospector: Managing a Very Low Cost Mission

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NASA Manager of LP from 1995-1998

The Master's Forum
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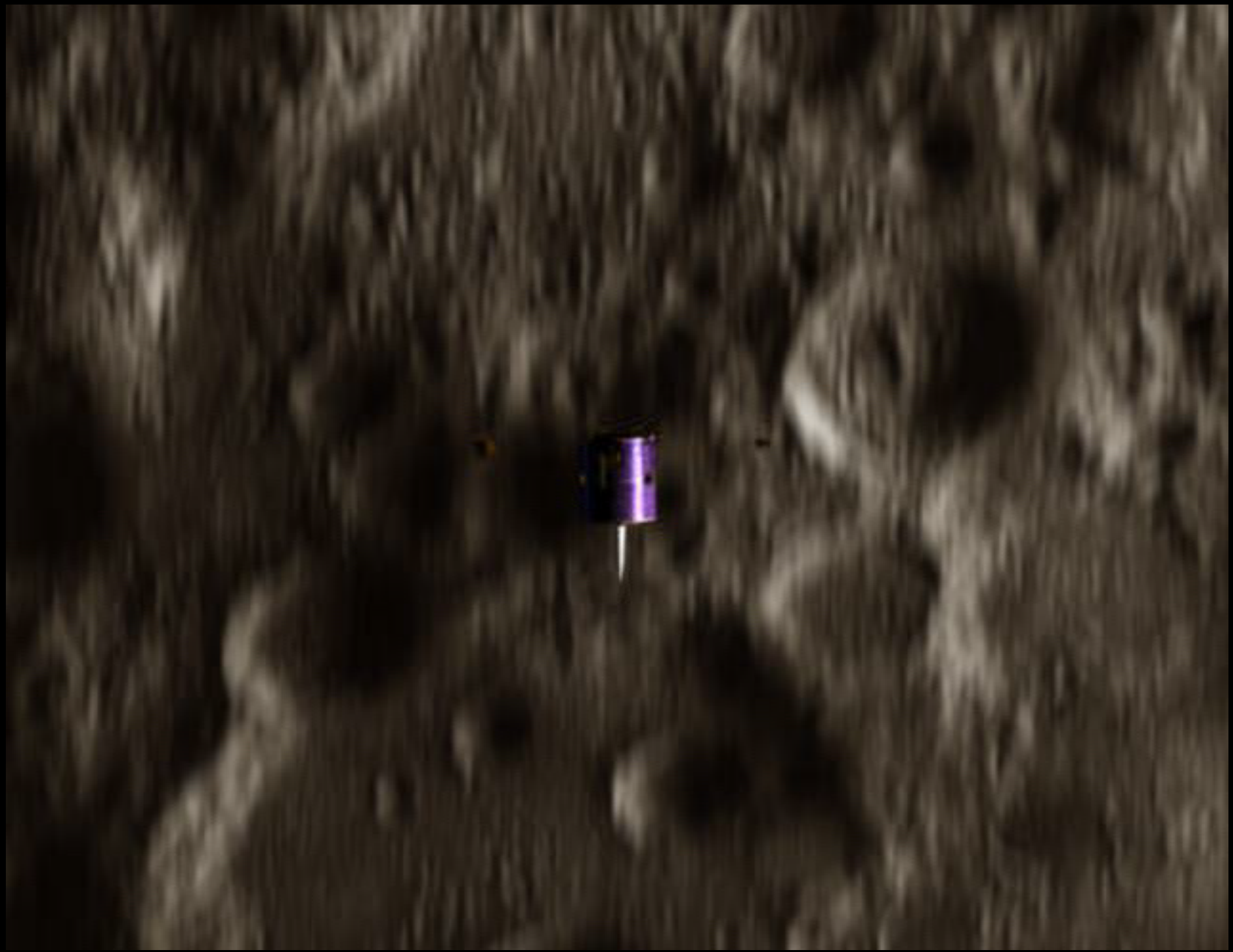
Mission and Program Goals

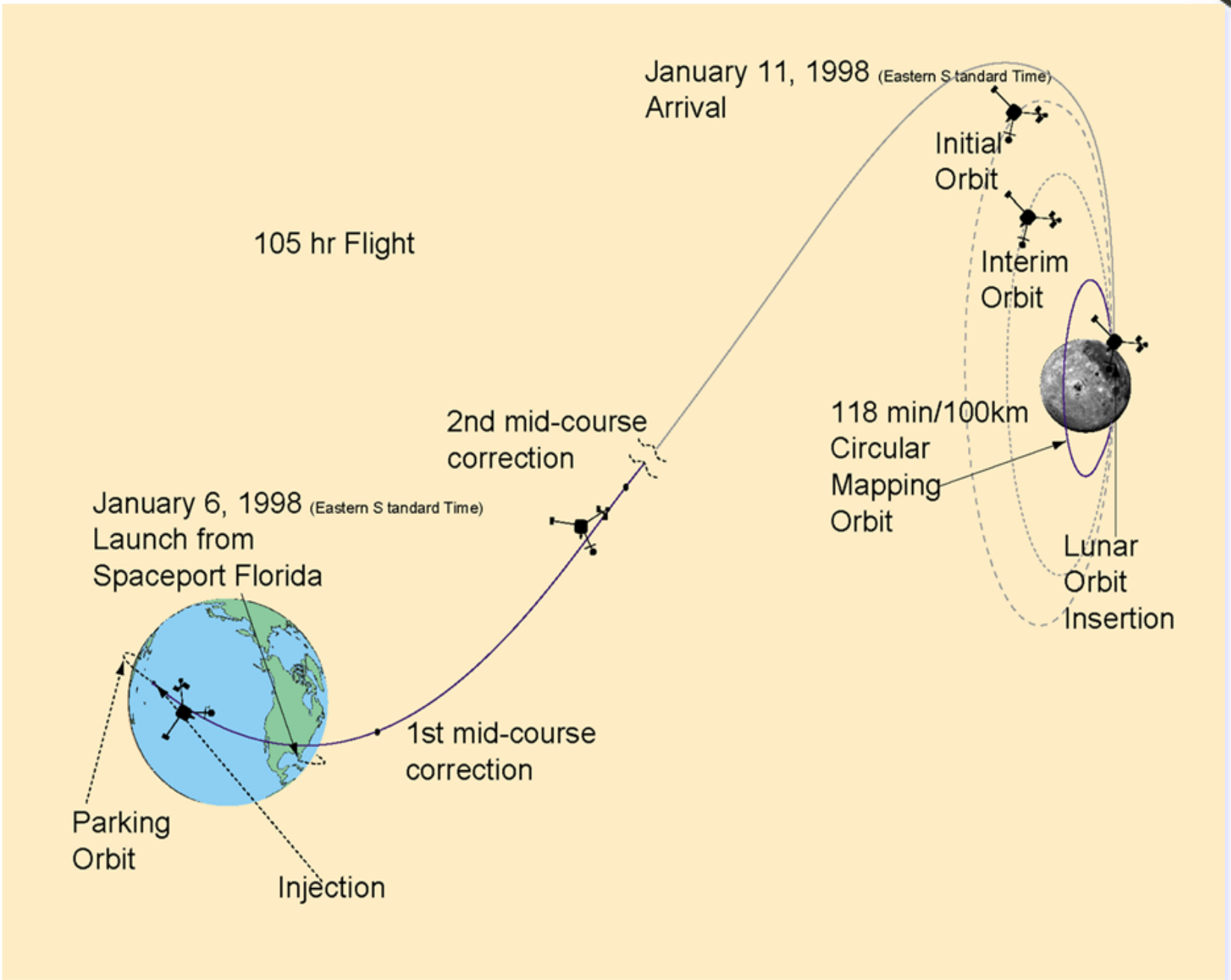
- Understand the origin, evolution and resources of the Moon
- Demonstrate "Faster, Better, Cheaper" goals of Discovery Missions
  - LP was the first competitively selected Discovery Mission
- Catalyze planetary exploration via education and outreach programs



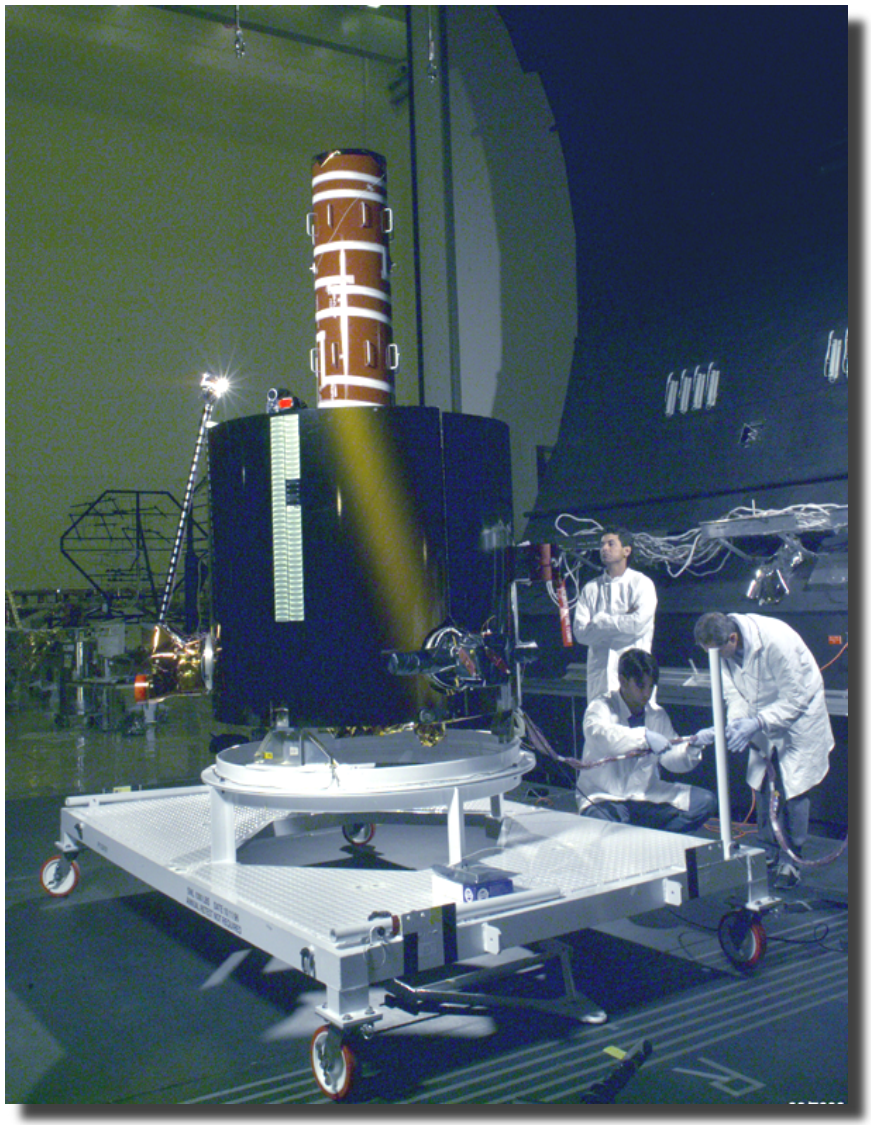
Mission and Metrics Overview

- $62.8M Total Mission Cost (FY96)
  - Phase B study: $2M
  - 5 Instruments/6 experiments: $3.6M
  - Spacecraft and mission analysis: $22.6
  - ELV, translunar stage and adapter: $26M
  - Operations: $4.2M
  - Maximum award fee: $4.4M
- Education and Outreach (example)
  - Innovative Web activities using ARC information technology
- 22 Month development
- 1 year primary mission at 100km circular polar orbit
- 6 month extended mission at 10-30 km polar orbit

Trajectory


January 11, 1998 (Eastern S tandard Time)
Arrival
Initial
Orbit
Interim
Orbit
105 hr Flight
2nd mid-course
correction
118 min/100km
Circular
Mapping
Orbit
Lunar
Orbit
Insertion
January 6, 1998 (Eastern S tandard Time)
Launch from
Spaceport Florida
1st mid-course
correction
Parking
Orbit
Injection

Development Approach



- **Spacecraft:**
  - Simple, spin-stabilized, reliable
  - High heritage instruments, components & subsystems
  - Mix of subsystem and operational redundancy
- **Test**
  - Rigorous test-as-you-fly program
  - Addressed all spacecraft functions and risk areas
  - No normal project steps were skipped

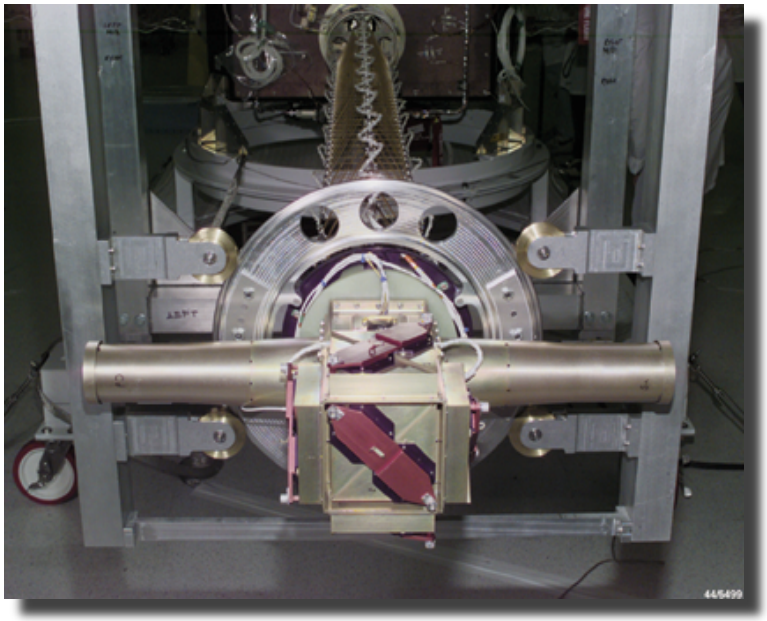
Mission Operations Approach

Mission Command & Control at Ames Research Center

- **Operations:**
  - Operational simplicity combined with planning, staffing and training of all aspects of operations
  - Extensive off-nominal system and mission analysis, contingency procedures development and team training
- **ELV:**
  - Athena II launch vehicle with commercial ship & shoot processes
  - Rigorous mission success qualification process

Management Challenges

- Manage to cost, yet maximize mission success on a short schedule
- Balance teamwork with NASA accountability
- Develop new management tools without sacrificing prudent process
- Accommodate new roles of PI and Project Manager



LP Management Philosophy

- Freeze project design and develop without deviation
- Minimize staff; place responsibility and accountability on front-line personnel (but maintain a mix of senior and junior staff)
- Maximize science per dollar via clear, firm objectives and metrics
  - Well-defined data return (e.g., global H maps to 50 ppm)
  - < 2 year development
  - $62.8M Total Mission Cost
  - New Education and Outreach mechanisms

Management Organization

Ames Research Ctr: Lunar Prospector Mission
Mission Manager: **Scott Hubbard**
Deputy Mission Manager: **Sylvia Cox**

Cost Plus Award Fee type contract

Lockheed/Martin: Lunar Prospector Project
PI: **Alan Binder***
Project Manager: **Tom Dougherty**

Co-Investigators and Instruments

Ames LP Team
-Mission/Trajectory Analysis
-Operations/Tracking Support

Spacecraft Development at LMMS

Launch Vehicle Development at LMA

* Now at Lunar Research Institute

Management Tools

- **Balance programmatic oversight with technical insight**
  - –Simplified reporting and monitoring systems
  - –Modified SR &QA surveillance
- **Use performance based award fee contract with cost and science incentives**
  - –Maximum award fee available (15%)
  - –1/2 award fee on Cost; fee reduced dollar for dollar by overruns
  - –1/2 on Science data, but if no science data, all award fee lost
- **Fixed price subcontracts**
- **Rapid movement of LMCO staff on and off project**

Insight vs Oversight

- Oversight/ Direct Involvement
  - –Proposed Science
  - –Top level schedule
  - –Total Mission Cost (TMC)
  - –Major Reviews (IRR)
  - –Athena II first use
  - –Tracking/DSN Ops
  - –SR & QA plan approval
- Insight/Vigilance
  - –Spacecraft Design Details (e.g.)
    - >Spacecraft moment of inertia
    - >C&DH breadboard FPGAs
    - >Solar cell selection
    - >Mast deployment
    - >GRS Thermal performance*
  - –Subcontract Selection and management
  - –Instrument Development
  - –SR & QA process monitoring

*Example of parallel analysis

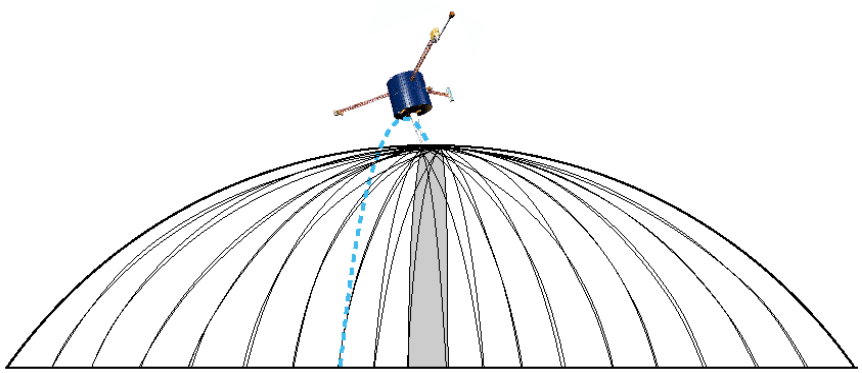
LP Management Approach

- Exploit proximity of PI/ Contractor-NASA management to streamline all processes
- Minimize NASA team size but maintain continuity; restrict parallel analysis
- Combine in-depth Independent Readiness Reviews (IRR) with normal prudent project milestone reviews
- Use existing contractor systems wherever possible

Metrics Status (Faster, Better Cheaper)

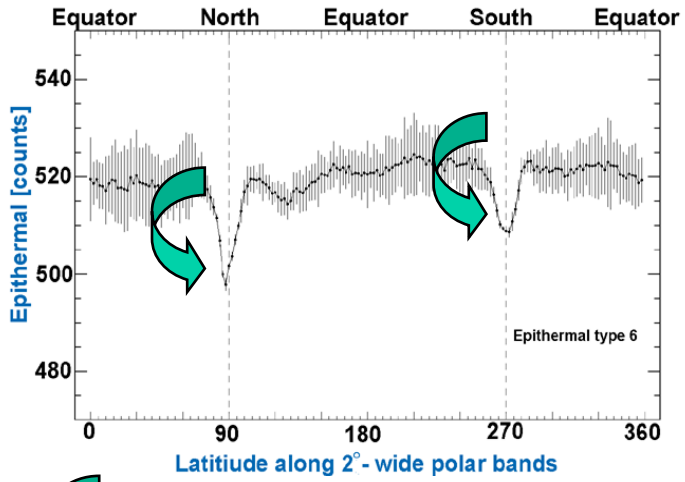
- Met goal of 22 month development through spacecraft test
- Project completed inside cost box and exceeded performance goals
- Athena II low cost launch vehicle first use successful
- Innovative website received >100M hits and won numerous awards

Science Return Example: Hydrogen/Water Ice



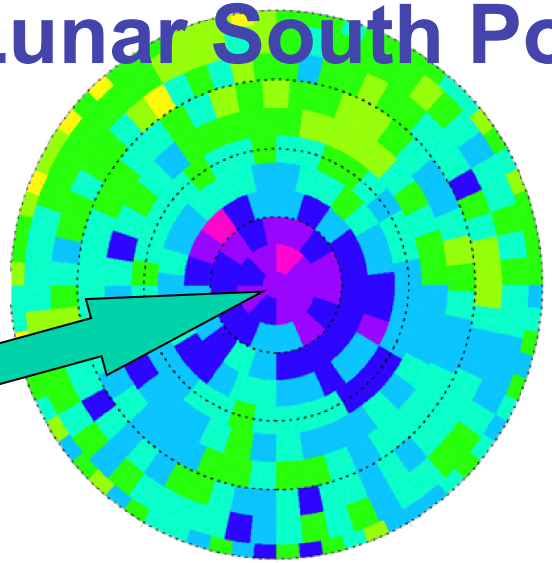
Neutron Spectrometer Data

- Circular polar orbit ensured high quality data from target polar regions
- Telltale dips in the counts of epithermal neutrons indicate excess hydrogen
- Large amounts of excess hydrogen are likely deposits of cometary water ice



Dips indicate presence of hydrogen = water ice

Lunar South Pole



Lessons Learned Assessment

- Discovery Program experiment and FBC worked, and:
  - Adequate reserves are key for even mature design
  - Personal "team chemistry" is important in small program
  - Risk management, including off-nominal assessment, must be considered continuously throughout program
  - Education and public outreach has become major effort

- Balance of management insight versus oversight must be appropriate for scope of program